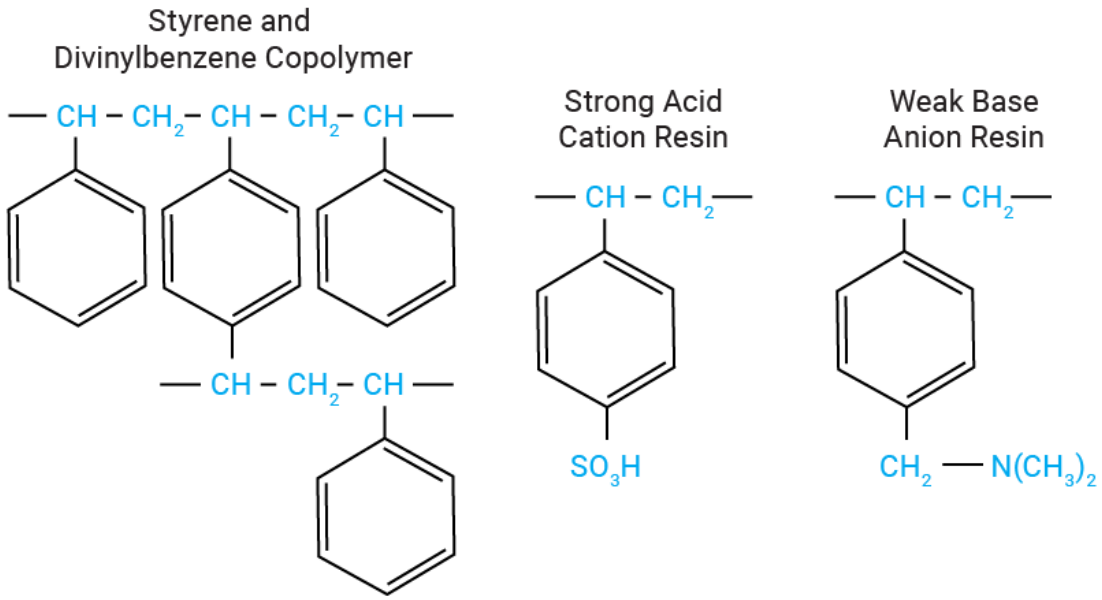
ENGINEERING CHEMISTRY

ION- EXCHANGE / DEMINERALISATION / DEIONIZATION PROCESS

- The presence of calcium (Ca) and/or magnesium (Mg) in water makes it hard.
- Calcium and magnesium ions in water react with heat, metallic plumbing, and chemical agents such as detergents to decrease the effectiveness of nearly any cleaning task.
- Hard water causes boiler troubles in the boiler. Therefore it should be softened before or after being fed into the boiler.
- Hard water can be softened using an ion exchange softening process.

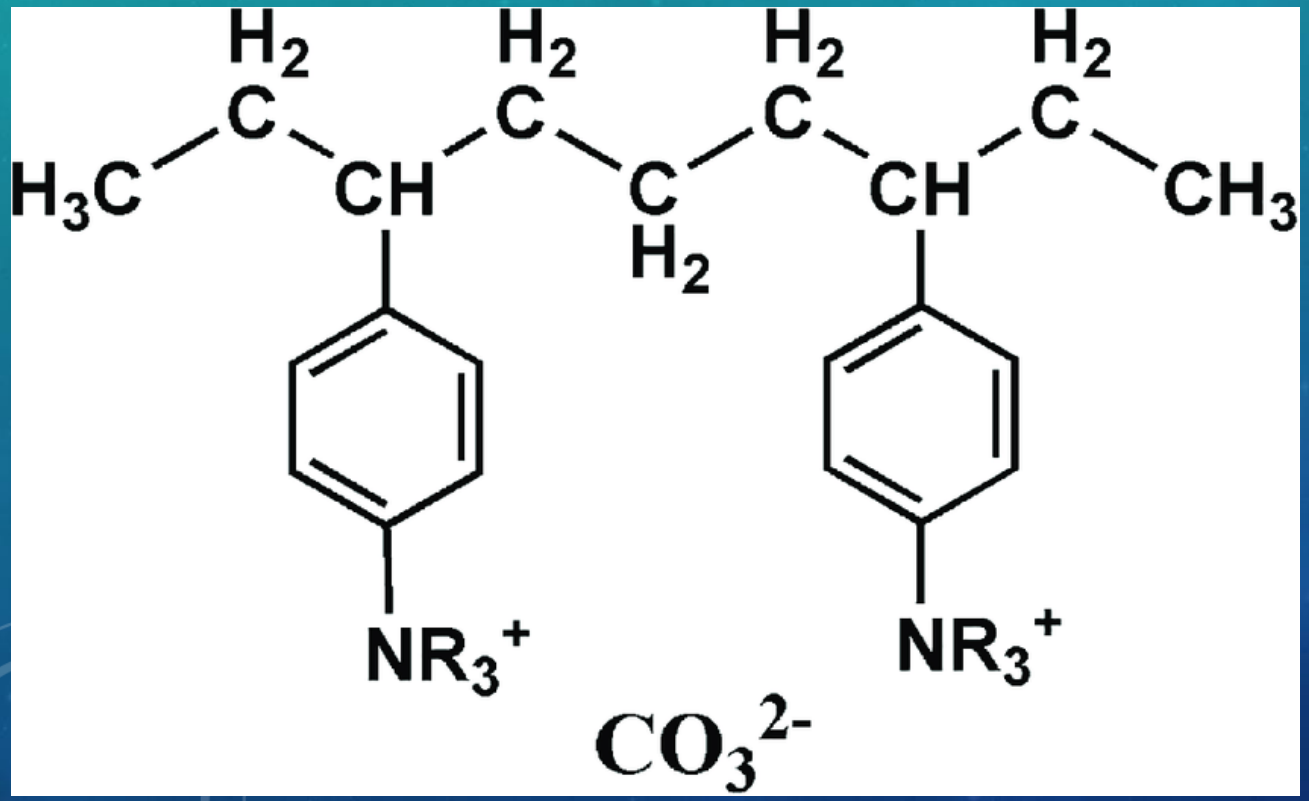
- In this process, ions held on a porous, essentially insoluble solid are exchanged for ions in solution that is brought in contact with it.
- The ion exchange water softening process can remove nearly all calcium and magnesium from source water.
- Ion Exchange resins are insoluble, cross – linked, high molecular weight, organic polymers with a porous structure and the functional groups attached to the chains have ion- exchange properties. The ion- exchange resins can be of two types:

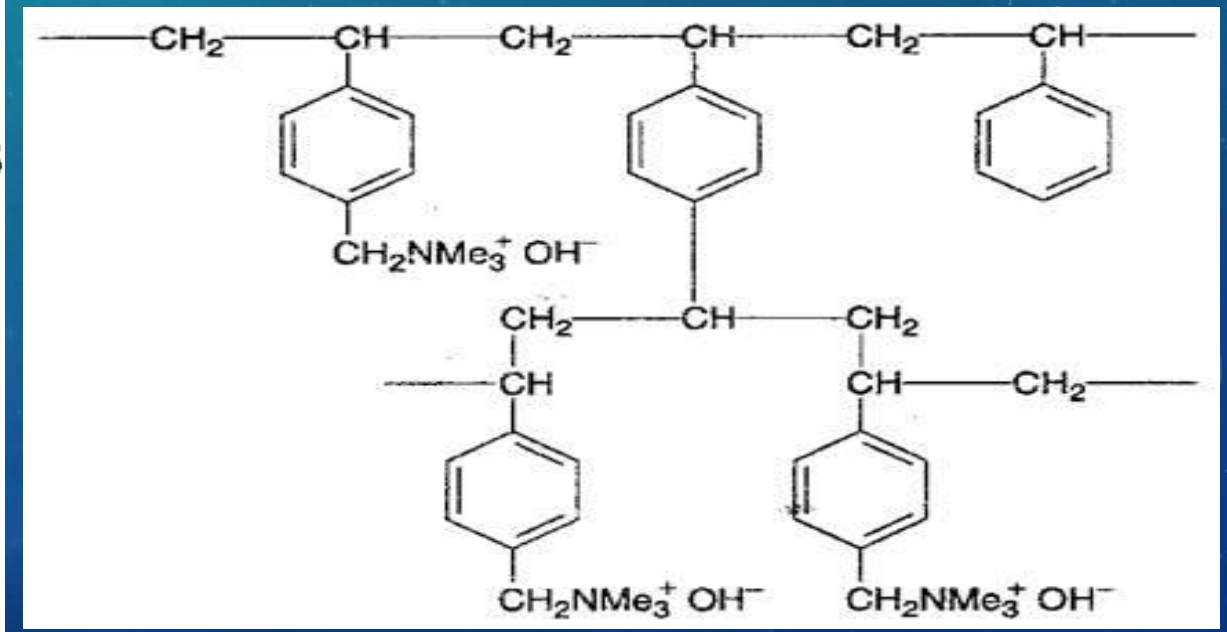
I. CATION EXCHANGE RESINS (R^-H^+)– These are styrene-divinyl benzene copolymers, which on sulphonation or carboxylation, become capable to exchange their hydrogen ions with the cations in the water.



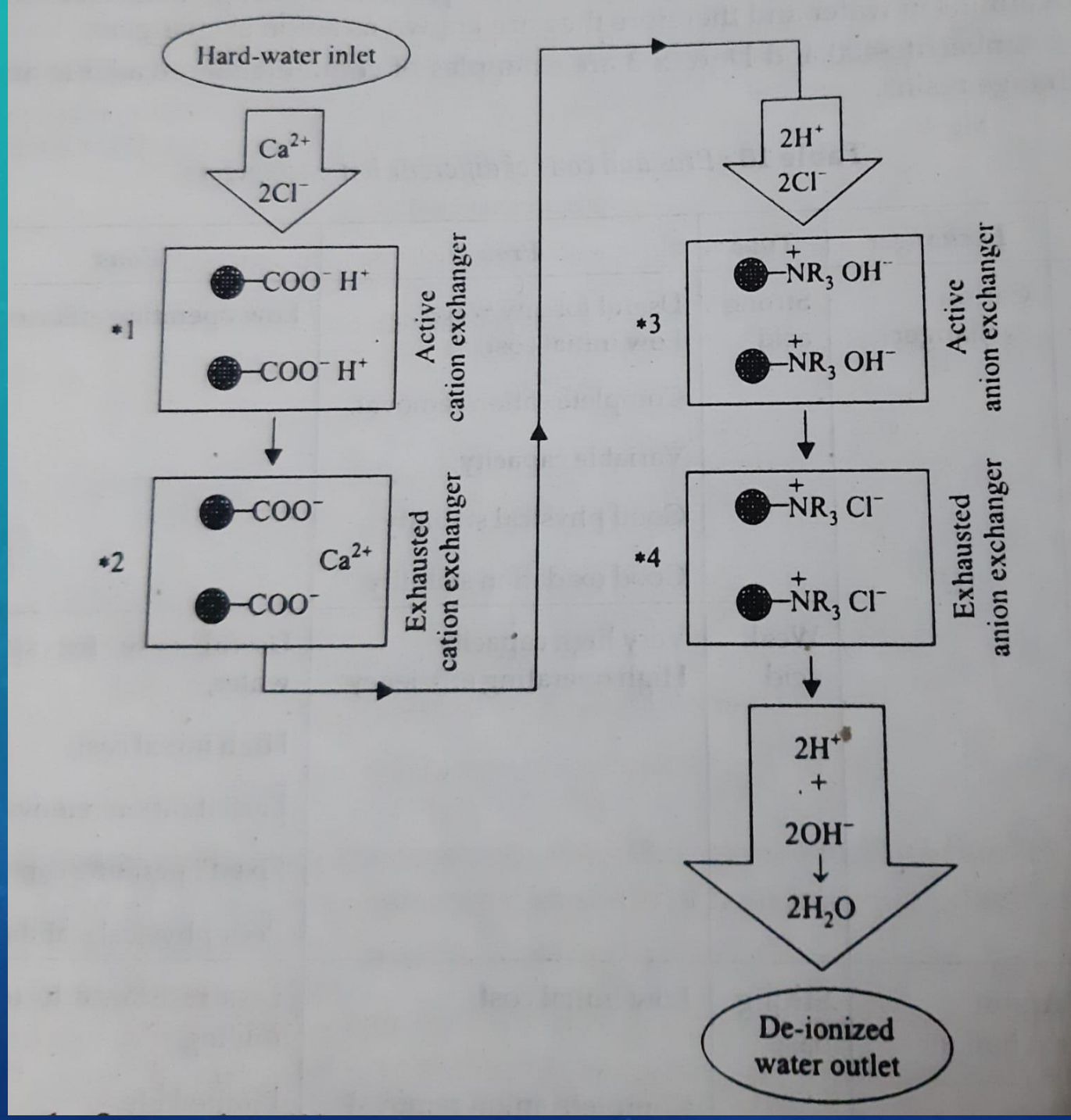
- Such resins have acidic functional groups like –SO3H, -COOH or –OH capable of exchanging the cationic portion of minerals by their hydrogen ions, and hence they are termed as cation exchangers.
- Examples: Amberlite IR- 120 and Dowex- 50

- ii. ANION EXCHANGE RESINS (R^+OH^-)- These are styrene- divinyl benzene or amine formaldehyde copolymers, which contain basic functional groups such as amino or quaternary ammonium $-N^+R_3$ or quaternary phosphonium or tertiary sulphonium groups as an integral part of the resin matrix. These, after treatment with dil. NaOH solution become, capable to exchange their OH- ions with anions in water and are known as anion exchange resins.
- Examples: Amberlite -400 and Dowex--30





- Process :The hard water is first passed through cation exchange resin, where all the cations like Calcium, magnesium ions are removed from it , and equivalent amount of H+ ions are removed from this column to water.
- After this the water is passed through the anion exchange column, when all the anions like sulphate, chloride etc present in water are removed and equivalent amount of OH- ions are released from this column to water.



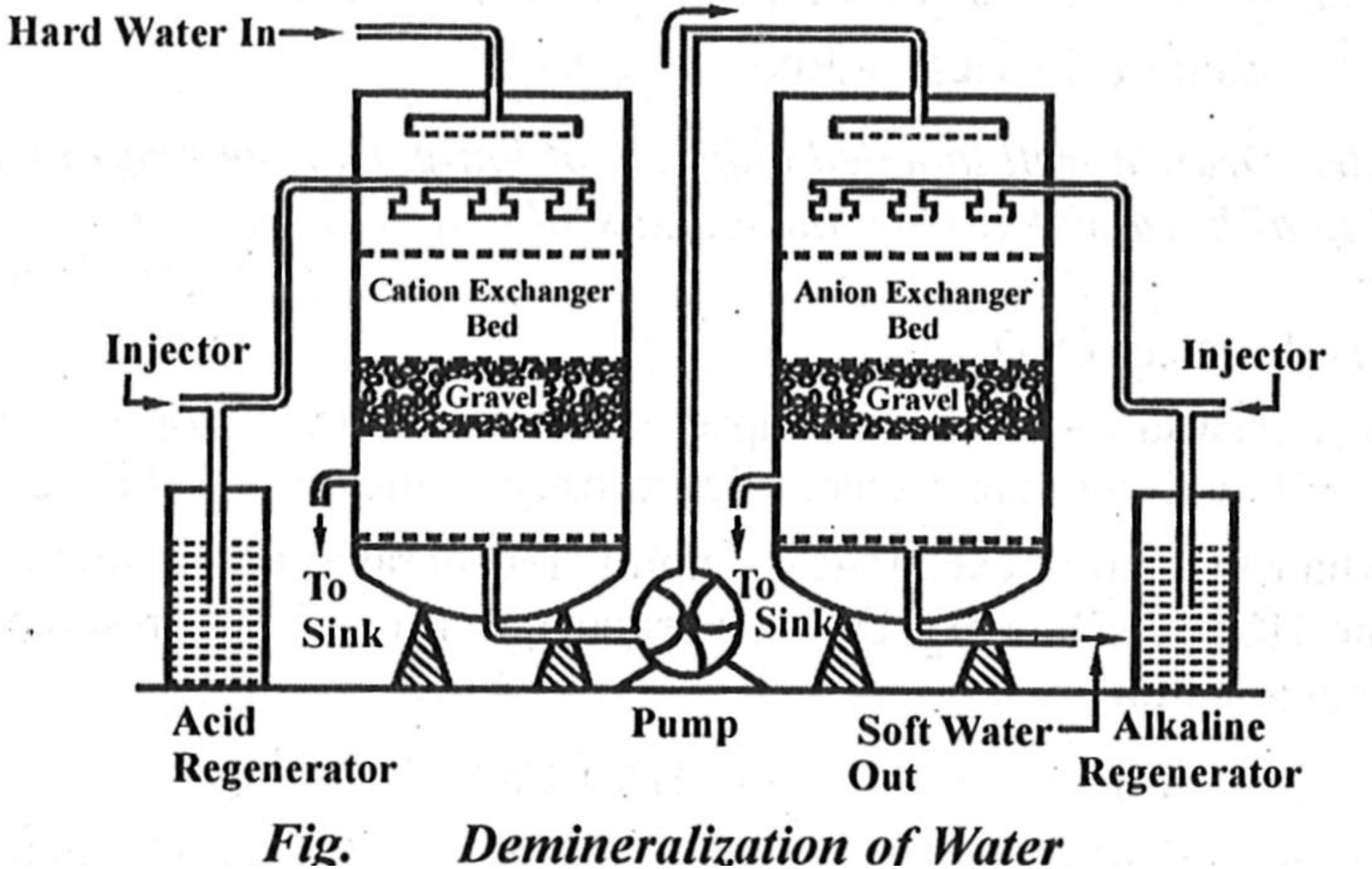


Fig. Demineralization of Water

- Now the H ions and OH ions released form the cation and anion exchange columns respectively get combined to produce water molecule.

$$H^+ + OH^- \longrightarrow H_2O$$

- Thus the water coming out from the exchanger is free from cations as well as anions. This ion free water is known as deionized or demineralized water and is also free from acidity or alkalinity. This water is as pure as distilled water.

- Regeneration: When all the cations and anions are exchanged by H and OH ions, the columns are said to be exhausted.
- The exhausted cation exchange column is regenerated by passing a solution of dilute HCL or dil. H2SO4.

$$(RSO^{-}_{3})_2\, M^{2+} + 2H^{+} \longrightarrow 2RSO^{-}_{3}H^{+} + M^{2+}$$

- The column is washed with deionized water and washing which contains cations is passed to drain.
- The exhausted anion exchange column is regenerated by passing a solution of dilute NaOH.

$$[RN^{+}(CH_3)_3]_2\, A^{2-} + 2OH^{-} \longrightarrow 2[RN^{+}(CH_3)_3]OH^{+} + A^{2-}$$

- The column is washed with deionized water and washing which contains anions is passed to drain.
- The regenerated ion exchange resins are then used again.

WHY IS WATER PASSED THROUGH CATION EXCHANGE COLUMN AND THEN THROUGH ANION EXCHANGE COLUMN AND NOT THE REVERSE WAY?

- This is because cation exchanger are easily attacked by alkalis, while all types of anion exchangers are not attacked by acids.
- This because when water is first passed through a cation exchanger, salts present in water are converted into corresponding acids, which on passing through the anion exchange column do not harm it.
- If the reverse sequence is used then on passing water through anion – exchanger, alkali is produced which harms the cation- exchanger in subsequent step. This is the reason, such a sequence is usually avoided.

Advantages

- This process can be used to soften highly acidic or alkaline water.
- It produces water of very low hardness around 2 ppm. Therefore treated water is very good for use in high pressure boilers.

Disadvantages

- The capital cost is high since chemicals and equipment both are costly.
- If the water contains turbidity then the efficiency of the process gets reduced.